



# **CNS revision (Part 3)**

**By**

**Dr. Amr Medhat Abbas**

**Professor of Medical Physiology**



# Hypothalamus

# Location of hypothalamus



- Hypothalamus is located at the base of brain, just above pituitary gland and below the thalamus on either side of the 3<sup>rd</sup> ventricle.



# Functions of hypothalamus

## 1- Regulation of autonomic nervous system

Hypothalamus controls the autonomic functions, as evidenced by the followings:

### *a) Stimulation of posterior hypothalamic area* →

sympathetic effects e.g. ↑ HR, ↑ ABP, pupillary dilatation & ↑ catecholamines secretion of from suprarenal medulla.

### *b) Stimulation of anterior hypothalamic area* →

parasympathetic effects e.g. ↓ HR, ↓ ABP.



## 2-Regulation of blood glucose level:

- Under normal conditions, glucose is the **only substrate used by the brain** for energy metabolism.
- It is supplied moment by moment due to **lack of glycogen stores.**
- Hypothalamus contains **glucoreceptors** stimulated by **hypoglycemia.**

-Hypoglycemia triggers counter-regulatory mechanisms to raise the blood glucose level.



- These mechanisms include:

a) ↑ secretion of adrenaline, growth hormone & cortisol → ↑ glycogenolysis, ↑ gluconeogenesis → ↑ blood glucose level to normal.

b) Activation of hunger center (in hypothalamus) → person feels hungry → ↑ food intake → ↑ blood glucose level.

### 3- Regulation of body osmolality and volume of body water:



- The hypothalamus regulates body osmolality and volume of body water by controlling both the output and the intake of water.

- This control is conducted by 2 mechanisms:

a) ADH

b) Thirst sensation (its center is in hypothalamus).

**When osmolarity increases  
& blood volume decreases**

- i-  $\uparrow$  **ADH** secretion  $\rightarrow$   $\uparrow$  **water reabsorption** from the kidney.
- ii-  $\uparrow$  **thirst** sensation  $\rightarrow$   $\uparrow$  **water intake**.
- Accordingly: blood volume  $\uparrow$ es & osmolarity  $\downarrow$ es to normal.

**When osmolarity decreases  
& blood volume increases**

- i-  $\downarrow$  **ADH** secretion  $\rightarrow$   $\uparrow$  **water loss** from the kidney.
- ii-  $\downarrow$  **thirst** sensation  $\rightarrow$   $\downarrow$  **water intake**.
- Accordingly blood volume  $\downarrow$ es & osmolarity  $\uparrow$ es to normal.

## 4- Regulation of endocrine glands:

### a) Hypothalamic control of anterior pituitary gland: (vascular control)

- Through the hypothalamo-hypophyseal portal circulation between the hypothalamus and the anterior pituitary (adenohypophysis).
- The hypothalamus secretes certain peptides which are transported to the pituitary gland through the hypothalamic –hypophyseal portal circulation.



## - These hypothalamic peptides are of two natures:

### a) Releasing factors (hormones):

- e.g.:
- Thyrotropin (TSH). RF
  - Corticotropin (ACTH). RF
  - Gonadotropin (GTH). RF
  - Growth H. RF

### b) Inhibiting factors (hormones):

- e.g.:
- Prolactin inhibiting factor (PIF).
  - Growth H inhibiting factor (GIF).

## b) Hypothalamic control of posterior pituitary gland: (Nervous control)



- A hypothalamo-hypophyseal tract arises from supra-optic (SO) and paraventricular (P.V) nuclei and ends in the posterior pituitary (neurohypophysis).
- The S.O nucleus secretes ADH and P.V nucleus secretes oxytocin. These hormones are then transported along the hypothalamic-hypophyseal tract to be stored in the posterior pituitary. Stimulation of S.O and P.V → release of these hormones from the posterior pituitary into blood stream.

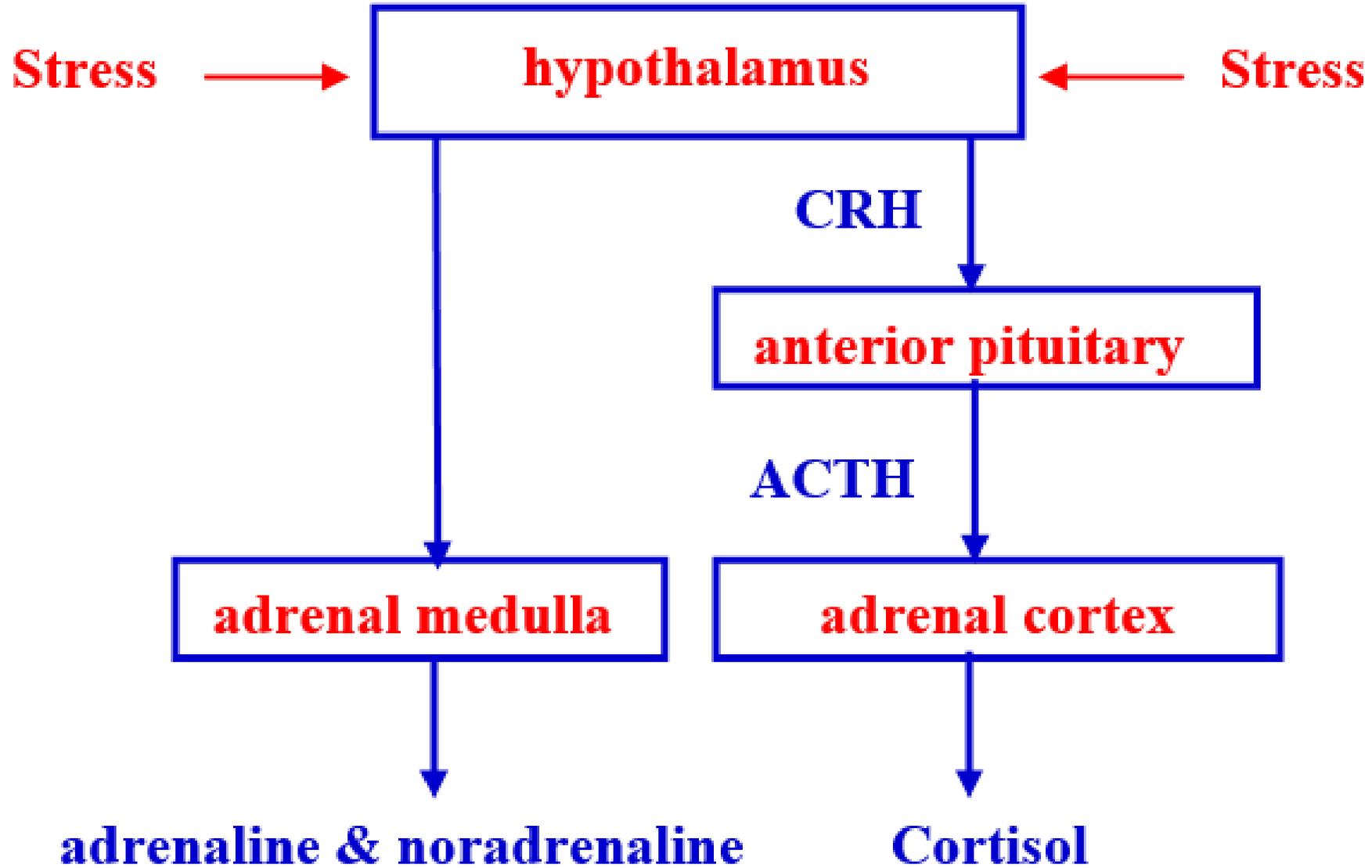
## c) Hypothalamic control of suprarenal medulla: (Nervous control)



- Hypothalamic fibers affect the adrenaline-secreting center in the medulla oblongata, which in turn affect the activity of SRM that secretes adrenaline and noradrenaline in the blood stream.

## 5- Regulation of body response to stress:

- Hypothalamus integrates both the endocrinal and neural responses to stress conditions e.g: hemorrhage, hypotension, hypoxia, hypoglycemia & muscular exercise.
- Hypothalamus stimulates the secretion of cortisol (from adrenal cortex) and adrenaline (from adrenal medulla) during exposure to stress.
- Both cortisol and adrenaline, participate in the defense against stress by several ways.



## 6- Role of hypothalamus in (diurnal) circadian rhythm:

- Several body functions undergo regular variation of their level within 24 hours of day e.g.

a) Body temperature

b) Blood pressure

c) Secretion of hormones as: cortisol, growth H, melatonin.

- The biological clock responsible for this regulation is the supra-chiasmatic nucleus (SCN) of hypothalamus which receives information about light and darkness directly from the retina of the eye.



**7- Regulation of body weight and food**

**intake.**

**8- Regulation of body temperature.**



# Limbic system



# Limbic system

The limbic system consists of parts of the brain that are important in:

1. Initiation of emotions.
2. Regulation of emotional behavior

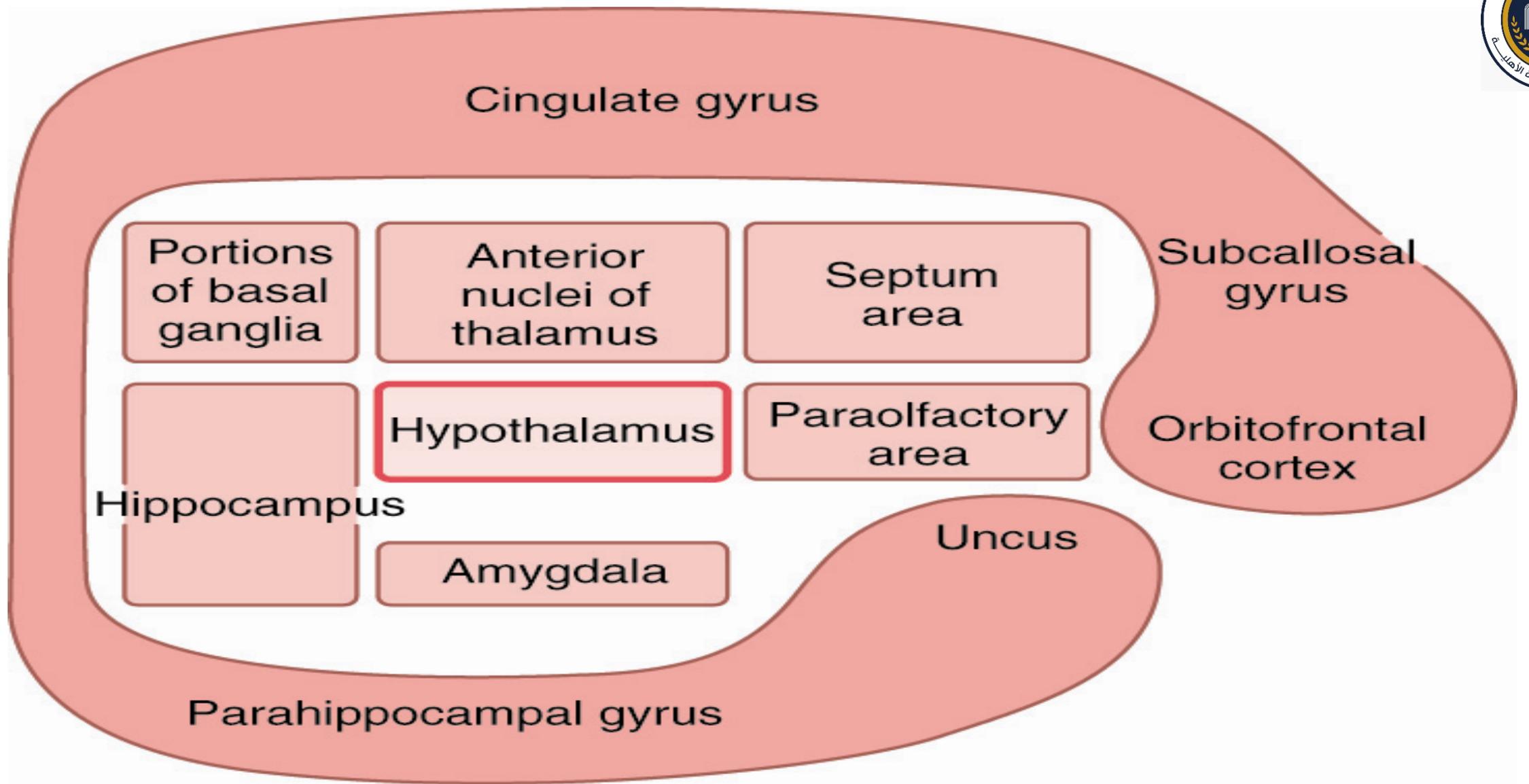
# Components of limbic system



## (I) Limbic cortex:

### - A ring of old cortex:

- Beginning in orbitofrontal area on the ventral surface of the frontal lobe.
- Extending upward in front and over the corpus callosum on the medial aspect of cerebral hemispheres to cingulate gyrus.
- Passing posteriorly to corpus callosum & downward on ventromedial surface of temporal lobe, to para-hippocampal gyrus, pyriform area & uncus.





## (II) Subcortical limbic structures:

- Thalamus
- Hypothalamus.
- Hippocampus.
- Amygdala
- Para-olfactory areas.
- Septal nucleus
- Parts of basal ganglia.

# Functions of limbic system



## \*Role of limbic system in motivation and emotional behavior:

The limbic system regulates patterns of behavior related to the following physiological functions:

# 1- Control of the feeding behaviour:

- This is one of the functions of amygdaloid nuclei.
- The amygdaloid nuclei differentiate food into edible and inedible on the basis of past experience.
- The stimulation of these nuclei causes chewing and licking movements, while its damage leads to hyperphagia associated with ingestion of all kinds of food and objects.

## 2- Fear and rage reactions:

- The limbic system receives information from different association areas of the cortex about various environmental stimuli.
- During exposure to threat, many limbic centers especially the amygdale, evoke protective emotional reactions (e.g. fear or rage reactions).

## Fear reaction

- If an animal is **threatened**, it usually tries to **escape**.

## Rage reaction

- If a threatened animal is **cornered**, it **attacks & fights**.

## Manifestations

Autonomic responses: as pupillary dilatation, sweating

Autonomic responses: as pupillary dilatation, hair erection

Somatic responses: as turning the head seeking escape.

Somatic responses: as biting.

### 3- Control of sexual behavior and reproduction:

#### ➤ Hypothalamus controls:

- a) Onset of puberty,
- b) Sexual function and activity.

➤ The behaviour components that accompany the sexual act are regulated by limbic cortex and hypothalamus as evidenced by:

- a) Bilateral damage of amygdale → hypersexuality.
- b) Removal of limbic cortex → loss of interest in other sex.

## 4- Punishment and reward response:

### A) Reward effect:

- Stimulation of certain areas in limbic system & hypothalamus, e.g. lateral, ventromedial nuclei of hypothalamus, amygdale and septal nuclei → pleasure and satisfaction (reward effect).

➤ The transmitter that is responsible for this sense is dopamine.



➤ The cocaine seems to produce its euphoric effect by increasing dopaminergic activity in the reward system.

## B) Punishment effect:

- Stimulation of certain areas in limbic system & hypothalamus, e.g. peri-aquiductal & periventricular areas → displeasure, rage, fear, escape (punishment effect) → avoidance of these punishing stimuli.

❖ So, there are 2 mechanisms in hypothalamus & limbic systems:



- The one promoting pleasure, comfort and placidity called reward or approach system whereas
- the other one promoting anxiety, fear and rage called punishment or avoidance system.
- So, emotional state is determined by the balance between the two systems.

# 5- Role of reward & punishment in learning & memory:



## ➤ Role in learning:

- Everything we do is related to reward and punishment. If we do something rewarding, we continue doing it and if we do something punishing, we stop doing it.

## ➤ Role in memory:

- If the stimulus causes neither reward nor punishment experience → can't be remembered easily i.e. no transformation into long-term memory and become hardly to be remembered.
- If the stimulus causes either reward or punishment → transformation of short-term memory into long-term memory and become hardly to be forgotten (remembered).

- The limbic system **differentiates** the sensory signals into **significant** ones which are **stored in memory** and **insignificant** ones which are **ignored**.
- **Damage of hippocampus** → anterograde amnesia.

## 6- Olfaction:

- Limbic system is concerned with perception and discrimination of different odours.
- It stores the olfactory memories and controls the emotional responses to olfactory stimuli.



# Cerebral cortex

# Functional areas of cerebral cortex



## □ Cerebral cortex could be divided into:

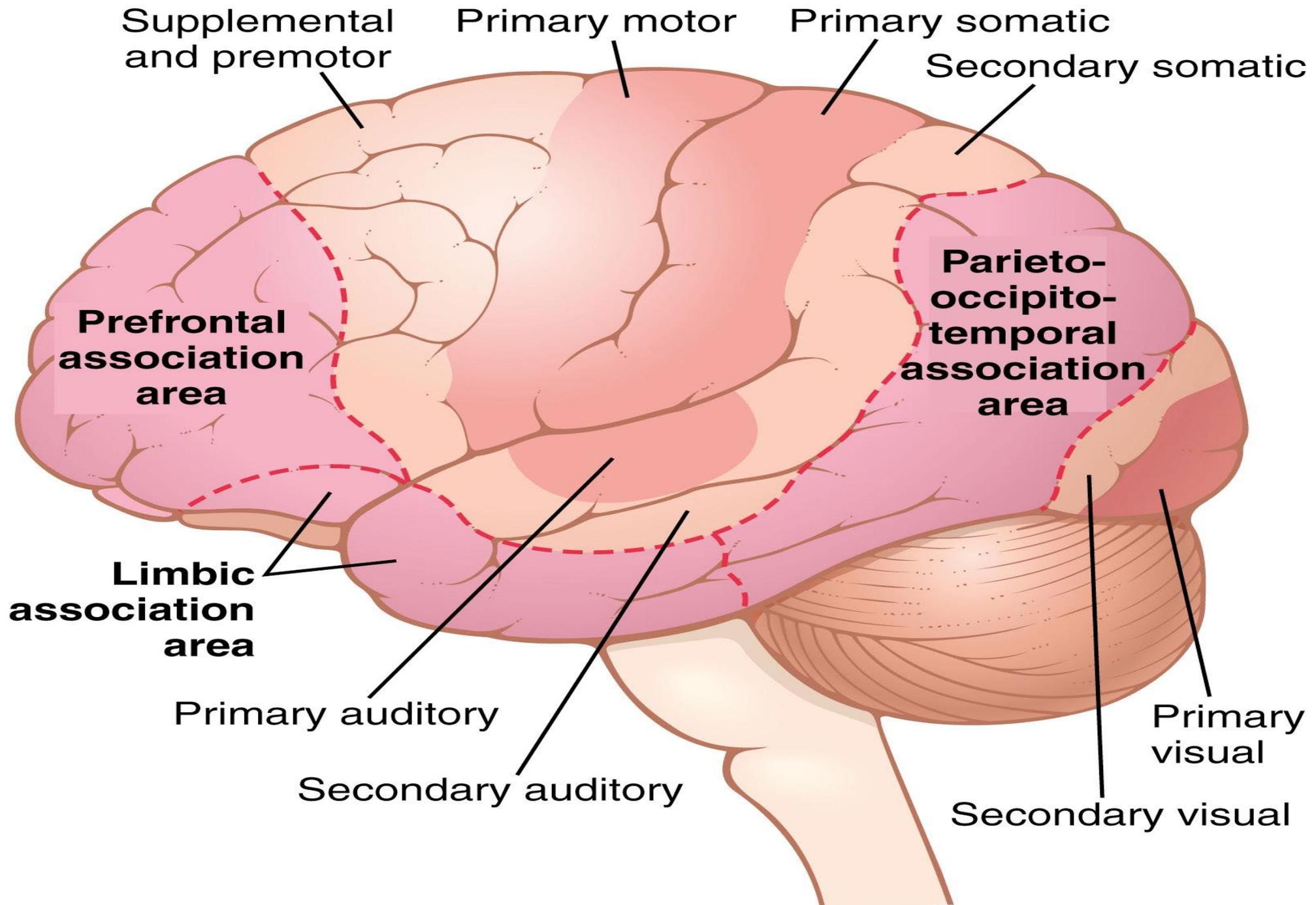
- Motor areas.
- Sensory areas.
- Limbic areas.
- Association areas.



# Cortical association areas

- They receive, analyze, and integrate signals from many regions of cerebral cortex and subcortical centers. The most important association areas are:

- 1) Parieto-occipito-temporal area.
- 2) Prefrontal association area.



# Parieto-occipito-temporal association area

➤ Site: located in the cortical region between different sensory areas of parietal, occipital and temporal lobes.

➤ Functions: It contains many functional areas as:

1- Area for analysis of body position.

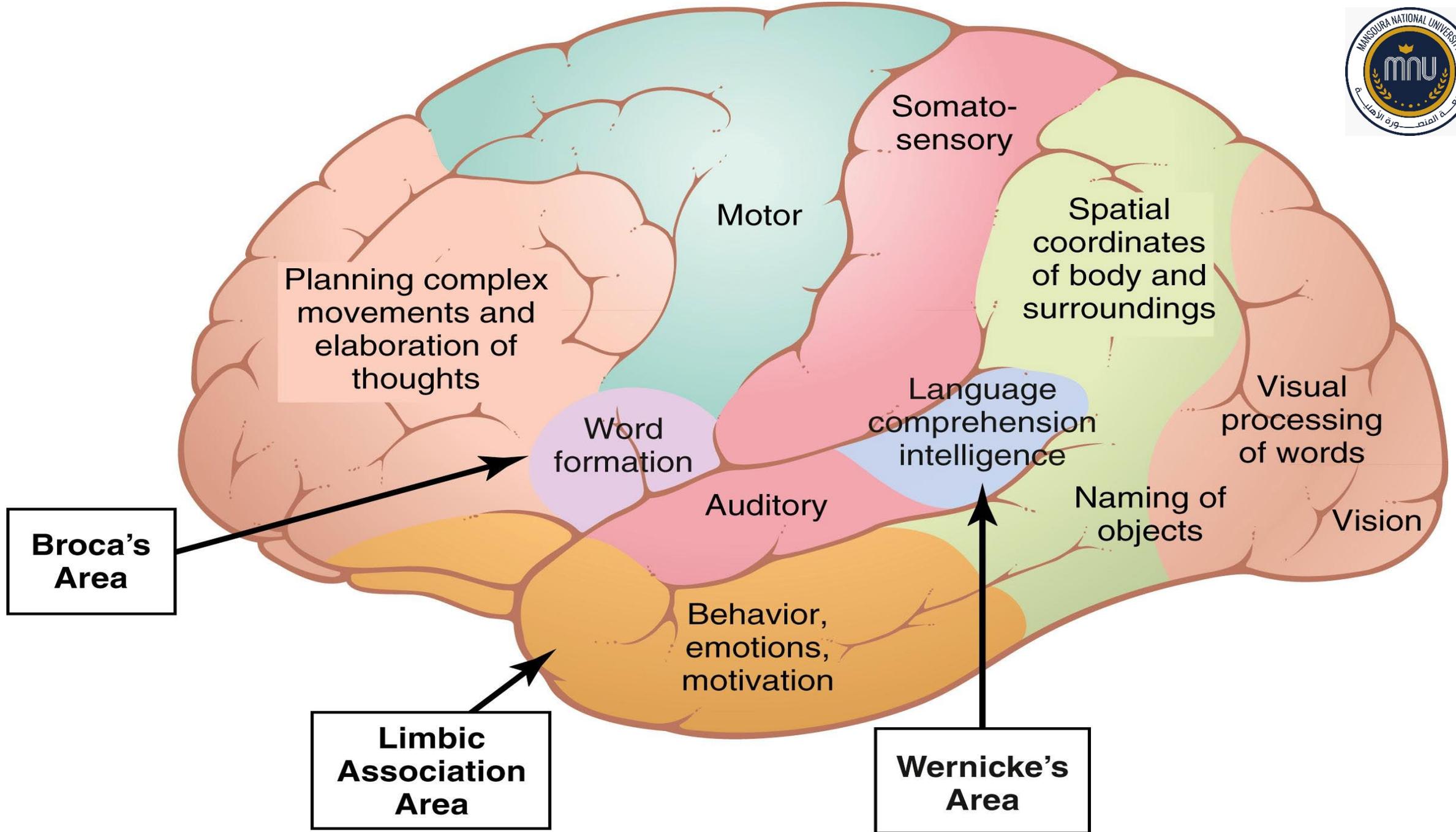
2- Reading area.

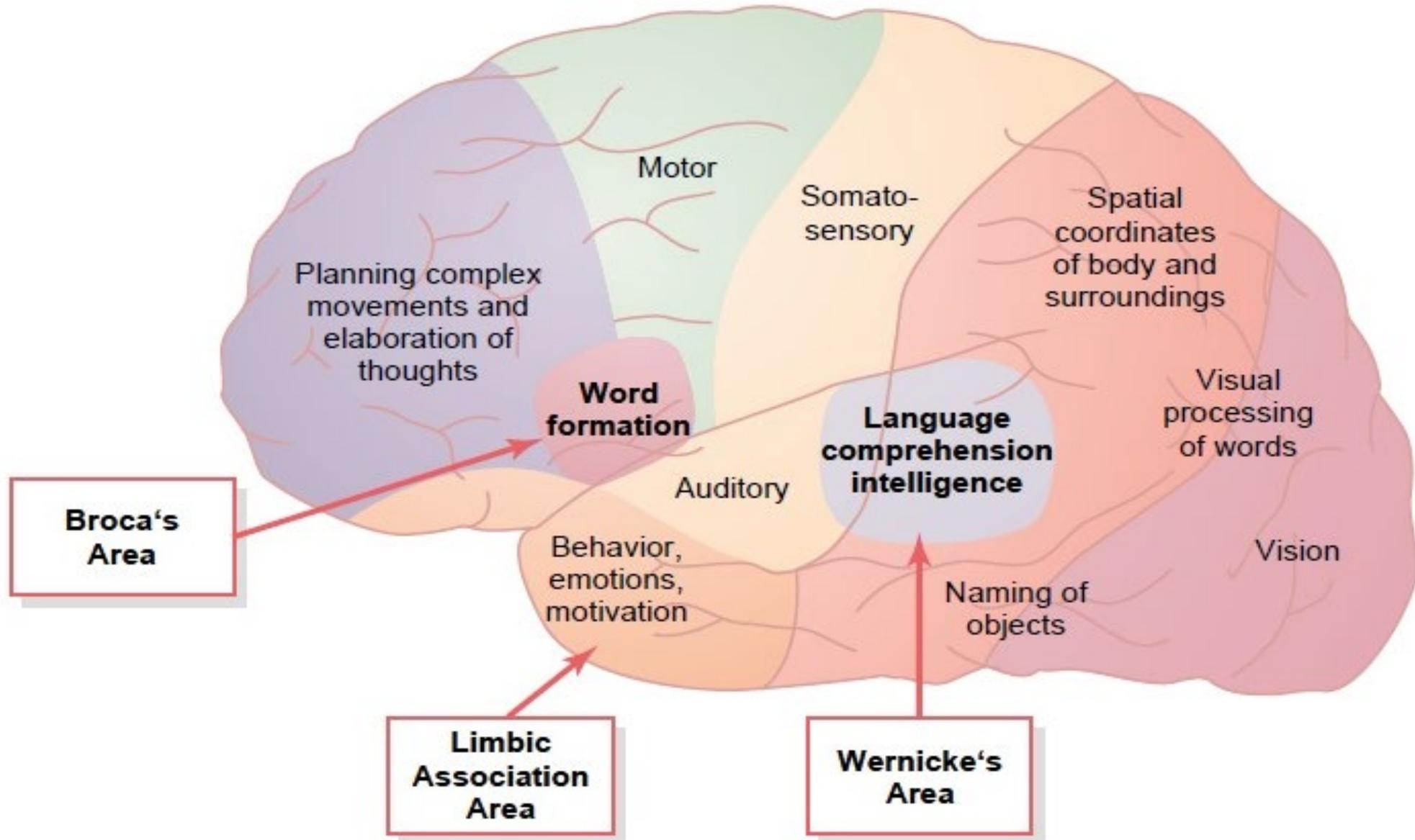
3-Area for naming of objects.

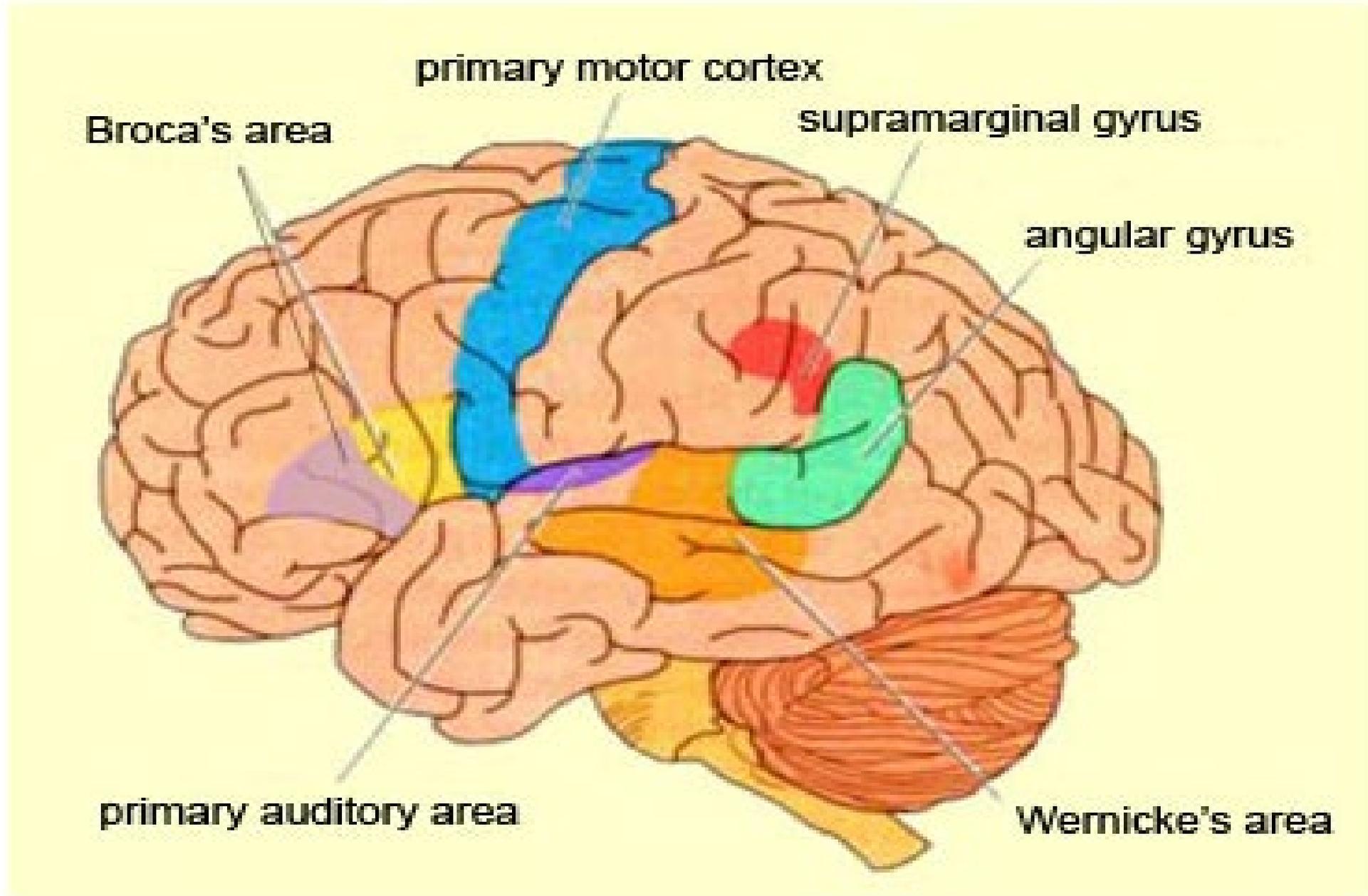
4- Area for recognition of faces.

5- Area for language comprehension = Wernicke 's area (General interpretative area).











# 1- Area for analysis of body position

- **Site:** Area between somatosensory area of parietal cortex and superior region of occipital cortex.

- **Function:**

It detects **body position** by interpretation of impulses from:

a) Visual receptors.

b) Proprioceptors.

## 2- Area for analysis of written words (Reading area)

- **Site:** Angular gyrus behind language comprehension area.
- **Function:** It recognizes meaning of perceived words during reading.
- **Lesion:** *word blindness (Dyslexia).*



# 3-Area for naming of objects



- **Site:** Inferolateral region of parieto-occipito-temporal area

- **Function:**

Associates *auditory input* with the *physical nature* of the object.

## 4- Area for recognition of faces

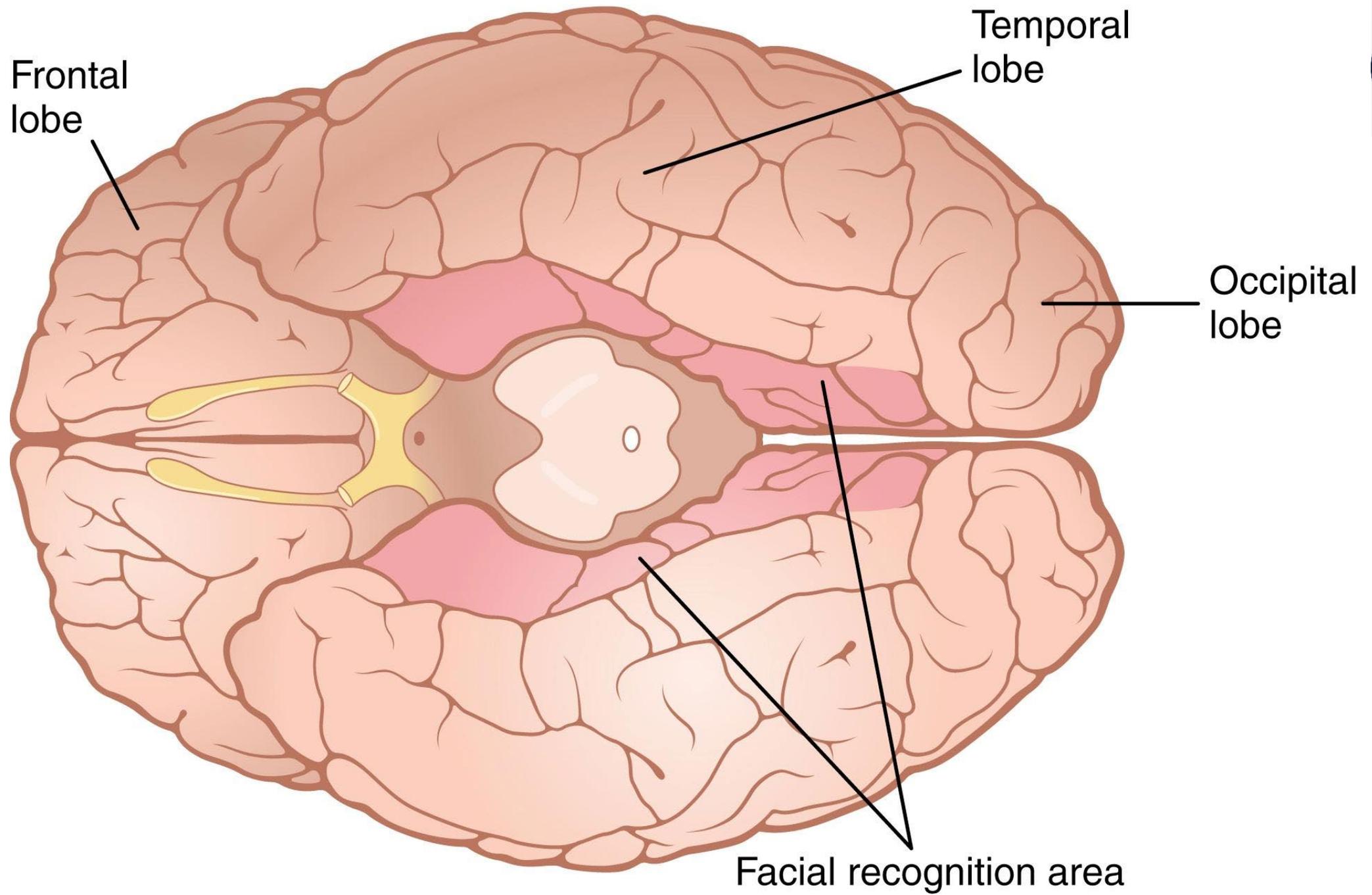


- **Site:** Medioventral surfaces of occipital and temporal lobes.

- **Function:**

It enables the person to *recognize familiar faces*.

- **Lesion:** → *prosopagnosia*



## 5- Area for language comprehension = Wernicke 's area (General interpretative area):



- **Site:** Posterior part of superior temporal gyrus

- **Function:**

- a) Higher levels of **language comprehension.**

- b) Understand **meanings** of spoken and written words

c) Formulation of thoughts and selection of *appropriate words* to express these thoughts in a *meaningful speech*.

d) Processing and recall of information stored in *memory*

**Lesion:** → deterioration of intellectual functions (language, thoughts) →

i) person is **unable to interpret** what is seen or heard

ii) person **can't express** himself **(Aphasia)**.

# Prefrontal association area



- Site: occupies anterior portion of frontal cortex.

- Functions:

- 1) Planning of complex pattern of voluntary movement: It receives **pre-analyzed sensory information** from parieto-occipito-temporal area about the position of different parts of body in relation to the surroundings → **motor plan** → cortical motor areas for performance of desired movement.



2) Sustains mental concentration

3) Elaboration of thoughts

4) Adjust the personal behavior:

- It interprets the ongoing events and makes predictions about future behavior.
- It adjusts the behavior according to social and moral basis.

**5) A working memory:** i.e. ability of prefrontal cortex to:



- **Collect** many bits of information simultaneously.
- **Store** it in a readily accessible temporary memory.
- **Recall** these information when needed.



- **Damage: leads to:**

- **Inability to plan** complex motor actions in proper sequence.
- **Mental distraction.**
- **Inappropriate social behaviour.**

# Neurological basis of language (Speech)



- **Def:** Language is highest mental function in humans, through which they can **express their thoughts** (communicate with each others) either by **spoken or written words.**
- Language is a **complex process** which requires integrity of whole cortex of **dominant cerebral hemisphere (left side in right-handed people and vice versa)** because it has both sensory and motor aspects.



- **Cortical areas involved in language:**

- I. Areas for language comprehension**

**(Sensory aspect)**

- II. Areas for language expression**

**(motor aspect)**

# I. Areas for language comprehension (Sensory aspect)



- Wernick's area receives input about both spoken words and written words from auditory and visual association areas, a pathway important in reading comprehension.
- Wernick's area is responsible for formulating coherent (Meaningful) pattern of speech.



## II. Areas for language expression (motor aspect)

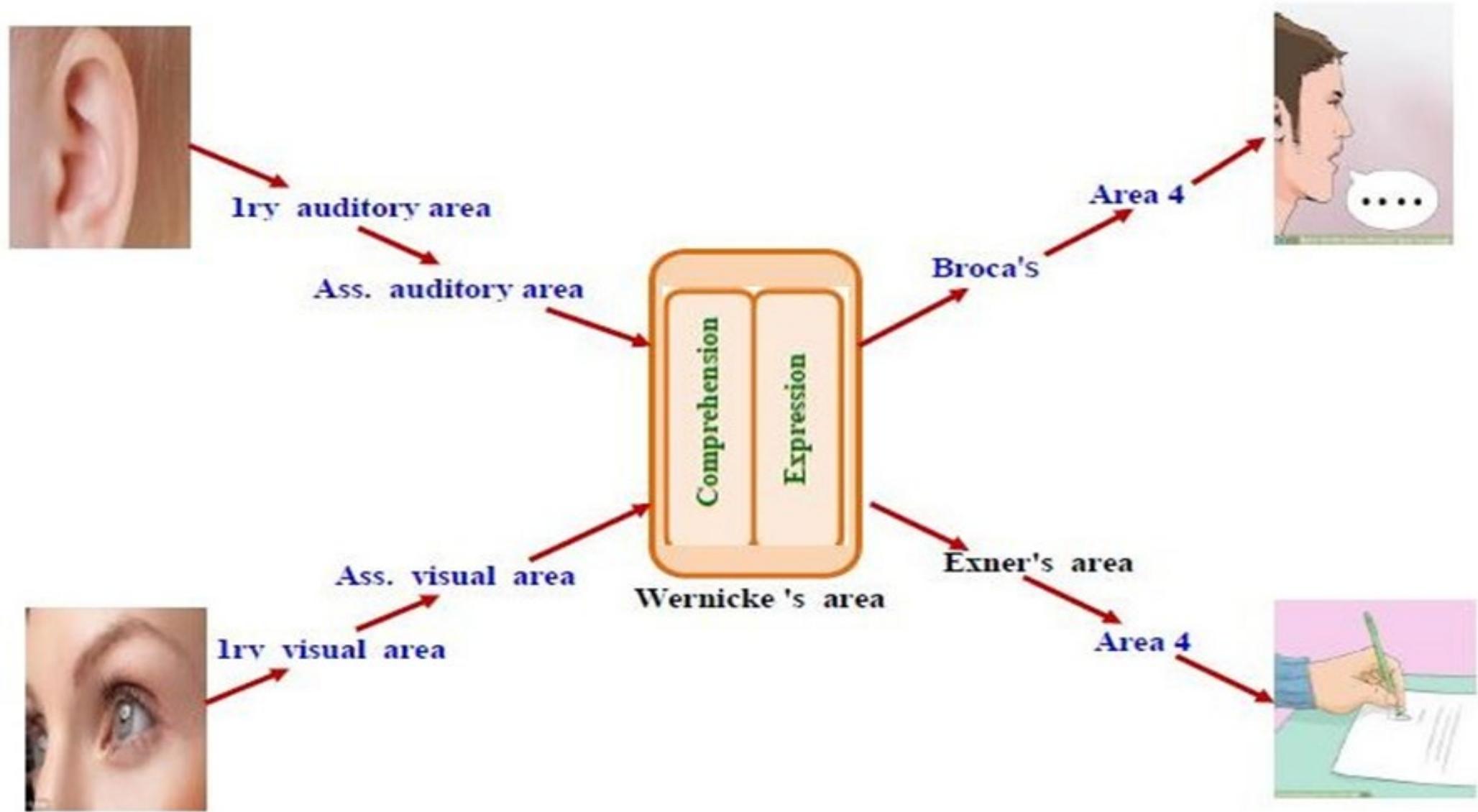
### a) Broca's area:

- **Site:** Located in posterior part of inferior frontal gyrus in dominant hemisphere just in front of primary motor cortex which initiates contraction of laryngeal and mouth muscles.
- **Function:** Broca's area integrates language signals received from Wernicke's area → transmit it into detailed coordinated pattern of motor commands → specific area in primary motor cortex (area 4) → initiation and coordination of appropriate contraction of muscles of lips, tongue and lower jaw → vocal production of speech.



## **b) Exner's area:**

- **Site:** Located in **frontal cortex in premotor cortex** immediately in front of region of primary motor cortex for hands and fingers.
- **Function:** When writing is needed, the language signals are transmitted from Wernick's area to **Exner's area** → **coordinates** the **skilled movements of hands and fingers** that are necessary for **writing**.



# Aphasia

- **Def:** Aphasia is a speech abnormality resulting from damage of specific language areas in the dominant hemisphere, NOT due to defects in vision or hearing or paralysis of the speech muscles.
- **Causes:** vascular stroke affecting cerebral blood vessels supplying this region.

## • Types:

### I- Receptive (Sensory) aphasia

#### *a) Auditory type:*

➤ Site of lesion: Auditory association area  
(area 22)

➤ Characteristics: Inability to understand  
spoken words (**auditory agnosia**).

## ***b) Visual type:***

➤ ***Site of lesion:*** Visual association area  
(area 18-19)

➤ ***Characteristics:*** Inability to  
understand written words (**visual  
agnosia**).

## c) Wernicke's type:

➤ Site of lesion: Wernicke's area

➤ Characteristics:

i- Inability to understand both spoken and written words.

ii- Inability to formulate speech.

## II- Expressive (Motor) aphasia

- Failure to articulate speech due to lesion at Broca's area (area 44-45)
- Failure of writing (agraphia) due to (lesion at Exner's area (area 46))

## III- Global aphasia (both types)

- Site of lesion: association area & motor areas
- Characteristics: Failure to understand or express thoughts.

# Sleep

- **Def:** It is a state of **unconsciousness** from which the person **can be aroused**.
- **Duration of sleep:** inversely related to age:
  - **Adults:** about 7-8 hours.
  - **Infants:** 18 hours.
  - **Old:** about 5-6 hours.
- **Types of sleep:**

There are **two types** of sleep that alternate with each other and are characterized by **different EEG patterns**.

1) **Non rapid eye movement sleep (NREM) = Slow-wave sleep (SW-sleep)** in which the brain waves are strong and of **low frequency**.

2) **Rapid eye movement sleep (REM sleep)** in which the **eyes** undergo **movements**

# Sleep

	Slow wave sleep (SW sleep)	Rapid eye movement sleep (REM sleep)
<b>Duration</b>	<b>90</b> minutes	<b>5-20</b> minutes
<b>Represent</b>	<b>75 %</b> of total sleep time	<b>25 %</b> of total sleep time
<b>Dreams</b>	May be associated with dreams but <b>not remembered</b>	Usually associated with <b>dreams</b> (vivid dreams) & nightmares
<b>Muscle tone</b>	<b>Mild</b> reduction	<b>Marked</b> reduction
<b>Heart rate, ABP &amp; resp rate</b>	<b>Mild</b> reduction	<b>Increase &amp; irregular</b>
<b>Rest</b>	<b>Restful</b> sleep	<b>Restless</b> sleep
<b>EEG waves</b>	<b>Slow</b> & high voltage	<b>Rapid</b> & low voltage
	As the <b>stages of SWS</b> proceed, it <b>become deeper &amp; restful</b>	The brain is highly active in this stage. <b>EEG</b> shows a pattern similar to alert state ( <b><math>\beta</math> rhythm</b> ).

# Basic theories of sleep

- Sleep is caused by **an active inhibitory process** and not simply **(Beside)** due to **fatigue of the reticular activating system (passive theory)**

## I. Initiation of NREM sleep:

Stimulation of many areas of the brain → sleep, **these areas include:**

### **1) Raphi nuclei in the lower half of the pons and in the medulla:**

- Nerve fibers from these nuclei spread locally in the **brain stem reticular formation** and upward into the **thalamus, hypothalamus, limbic system** and even **cortex**.
- The endings of these nuclei fibers **release serotonin** which is the transmitter producing sleep.

### **2) Nucleus of the tractus solitarius** in the medulla.

# Basic theories of sleep

## II. Initiation of REM sleep:

- REM sleep is **initiated** by **↑** activity of **cholinergic neurons** located in the **upper brain stem reticular formation**.
- These neurons (**REM-On neurons**) send **excitatory** signals **to RAS, thalamus as well as cerebral cortex**.

## III. Termination of REM sleep:

- The **termination of the REM sleep** results from **↑** activity of the **serotonergic neurons in the raphi nuclei** which **send inhibitory** projections to **the cholinergic neurons in the RAS**.